METHOD OF TREATING NONWOVEN FABRICS WITH NON-IONIC FLUOROPOLYMERS

TECHNICAL FIELD

This invention relates to nonwoven fabrics and to methods of treating nonwoven fabrics.

BACKGROUND OF THE INVENTION

The manufacture of nonwoven fabrics for diverse applications has become a highly developed technology. Methods of manufacturing nonwoven fabrics include spunbonding, meltblowing, carding, airlaying, and so forth. It is not always possible, however, to produce by these methods a nonwoven fabric having all desired attributes for a given application. As a result, it is often necessary to treat nonwoven fabrics by various means to impart desired properties. For example, for medical applications such as surgeon's gowns, barrier properties to alcohol and blood penetration and bacteria are desired, and antistatic properties are important as well. Unfortunately, treatments for barrier properties using fluorocarbons, for example, and treatments for antistatic properties using salts are detrimental to each other which makes it necessary to apply excessive amounts of one or both of the treatments. Current methods of treating nonwoven fabrics require slightly to moderately charged, either cationic or anionic, fluoropolymers suspended in water and then combined with anionic antistatic agents in a single bath treatment to produce an alcohol repellent, antistatic surgical fabric. Unfortunately, the antistatic agents currently being used are surface active in nature and negatively impact the water repellency of the finished web as measured by hydrostatic head testing. In addition, the antistatic agents

tend to destabilize ionic fluoropolymer suspensions, leading to coagulation and filter plugging issues. Efforts to completely remove the antistat from the bath and apply it downstream on the body side of the web have resulted in a loss of alcohol repellency at equivalent fluoropolymer bath concentrations due to low adsorbed amounts of fluoropolymer on the fabric.

Accordingly, there is a need for a method of topically treating surgical fabric with an alcohol repellent chemistry that does not negatively effect the water barrier of the fabric.

SUMMARY OF THE INVENTION

The present invention provides a method of treating nonwoven fabric with an alcohol repellent chemistry. In one embodiment, the method of the present invention includes contacting a substrate with a treatment solution comprising a non-ionic fluoropolymer and water wherein the treatment solution contains no or less than about 0.05 weight percent by weight of an antistatic agent. The nonwoven substrate can be or include a nonwoven fabric laminate, such as a spunbond/meltblown (SM) laminate, a spunbond/meltblown/spunbond (SMS) laminate, a spunbond/film/spunbond (SFS) laminate, a spunbond/film/spunbond/meltblown/spunbond (SFSMS) laminate or a spunbond/film/film/spunbond (SFFS) laminate. Treated fabric laminates of the present invention are useful as surgical fabrics.

In one embodiment, the present invention provides a method of treating a nonwoven fabric to improve the alcohol repellency of the nonwoven fabric while minimizing any negative effect of the treatment on the water repellency of the nonwoven fabric, the method including contacting a nonwoven fabric with an aqueous treatment solution that includes from about 0.1 weight percent to about 0.9 weight percent of a

non-ionic fluoropolymer and essentially no antistatic agent or less than 0.05 weight percent of an antistatic agent, wherein the hydrostatic head value of the treated nonwoven fabric drops by no more than 45 percent relative to the hydrostatic head value of the untreated nonwoven fabric. Desirably, the hydrostatic head value of the treated nonwoven fabric drops by no more than 30 percent relative to the hydrostatic head value of the untreated nonwoven fabric, more desirably by no more than 25 percent, even more desirably by no more than 20 percent, still more desirably by no more than 15 percent and most desirably by no more than 10 percent relative to the hydrostatic head value of the untreated nonwoven fabric. The treatment solution can be an aqueous treatment solution and include dipping or running the nonwoven fabric or a portion of the nonwoven fabric in to a container of the aqueous treatment solution. Desirably, the aqueous treatment solution is a stable dispersion of non-ionic fluoropolymer in water and wherein the hydrostatic head value of the treated nonwoven fabric drops by no more than 25 percent relative to the hydrostatic head value of the untreated nonwoven fabric. The nonwoven fabric can be selected from the group consisting of spunbond fabrics, meltblown fabrics and laminates thereof. Desirably the treatment solution includes less than 0.005 weight percent by weight of an antistatic agent. More desirably, the treatment solution includes no antistatic agent and the method further includes contacting the nonwoven fabric with a second solution that includes an antistatic agent in a later process step. For example, it is suggested that the method further includes contacting one side of the treated nonwoven fabric with a second treatment comprising an antistatic agent to improve antistatic properties. Desirably, the hydrostatic head value of the treated nonwoven fabric drops by no more than 10 percent relative to the hydrostatic head value of the untreated nonwoven fabric. The antistatic agent can be an organic phosphate ester. In at least one embodiment, the present invention provides a treated nonwoven fabric with improved alcohol repellency that has a hydrostatic head

value of greater than 45 mBar as measured by Federal Test Standard 191A, Method 5514. More desirably, the present invention provides a treated nonwoven fabric that has an alcohol repellency of at least 70 percent as measured by INDA Standard Test No. IST 80.9-74 (R-82) and a hydrostatic head value of greater than 45 mBar as measured by Federal Test Standard 191A, Method 5514 and the hydrostatic head value of the nonwoven fabric is decreased by less than 10 percent relative to the untreated nonwoven fabric. Still more desirably, the treated nonwoven fabric has an alcohol repellency of at least 75 percent as measured by INDA Standard Test No. IST 80.9-74 (R-82) and a hydrostatic head value of greater than 45 mBar as measured by Federal Test Standard 191A, Method 5514. The nonwoven fabric can be a laminate that includes at least one spunbond layer and more desirably at least one meltblown layer. For example, the nonwoven fabric can be an infection control fabric that is or includes a spunbond/meltblown/spunbond laminate, a spunbond/film/spunbond laminate, a spunbond/film/spunbond/meltblown/spunbond laminate or a spunbond/film/film/spunbond laminate. In some embodiments, the treatment solution includes greater than about 0.15 weight percent of a non-ionic fluoropolymer or a mixture of non-ionic fluoropolymers. In other embodiments, the treatment solution includes greater than about 0.20 weight percent of a non-ionic fluoropolymer or a mixture of non-ionic fluoropolymers. In still other embodiments, the treatment solution includes greater than about 0.25 weight percent of a non-ionic fluoropolymer or a mixture of non-ionic fluoropolymers. The treatment solution may further include an optional alcohol, for example an alkyl alcohol. The non-ionic fluoropolymer or fluorpolymers can be selected from the group consisting of fluoroalkyl acrylate homopolymers, fluoroalkyl acrylate copolymers, fluorinated siloxanes, fluorinated silicones, fluorinated urethanes, and mixtures thereof. In at least one embodiment, the non-ionic fluoropolymer is a non-ionic fluoroalkyl acrylate copolymer.

The present invention also provides nonwoven fabrics treated according to the methods of the present invention, particularly nonwoven fabrics that are adapted for use as an infection control product. In one desirable embodiment, the nonwoven fabric includes a first surface and a second, opposing surface wherein the first surface includes a non-ionic fluoropolymer and the second surface includes an antistatic agent. The nonwoven fabric can be a laminate or a portion of a laminate.

In still another embodiment, present invention provides a method of improving the alcohol repellency of a nonwoven laminate by applying a topical treatment to a nonwoven laminate while minimizing any negative effect of the topical treatment on the water repellency of the nonwoven laminate, the method including the steps of:

providing a nonwoven laminate; contacting an aqueous treatment solution that includes from about 0.20 weight percent to about 5 weight percent of a non-ionic fluoropolymer or a mixture of non-ionic fluoropolymers with the nonwoven laminate or a portion of the nonwoven laminate where the non-ionic fluoropolymers are selected from the group consisting of non-ionic fluoroalkyl acrylate homopolymers, fluoroalkyl acrylate copolymers, fluorinated siloxanes, fluorinated silicones, fluorinated urethanes, and mixtures thereof; and then contacting a surface of the topically treated nonwoven laminate with an antistatic agent selected from the group consisting of organic phosphate esters.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood and further advantages will become apparent when reference is made to various embodiments described in the following description and accompanying drawings in which:

Figure 1 is a schematic of one treatment process embodiment of the present invention using a saturation treatment step followed by a spray treatment step.

Figure 2 is a schematic of a second treatment process embodiment of the present invention using a foam applicator instead of a spray treatment step.

Figure 3 is a schematic of an exemplary second step of a process of the invention using ink jet treating.

Figure 4 is a schematic of a third treatment embodiment of the present invention applying antistat and repellent treatments to opposite sides.

Repeated use of reference characters in the present specification and drawings is intended to represent same or analogous features or elements of the present invention.

Test Procedures

Hydrostatic Head: A measure of the liquid barrier properties of a fabric is the hydrostatic head test. The hydrostatic head test determines the height of water (in centimeters) which the fabric will support before a predetermined amount of liquid passes through. A fabric with a higher hydrostatic head reading indicates it has a greater barrier to liquid penetration than a fabric with a lower hydrostatic head. The hydrostatic head test is performed according to Federal Test Standard 191A, Method 5514.

The test is modified to include a screen support of standard synthetic fiber window screen material. The test head of a Textest FX-300 Hydrostatic Head Tester, available from Schmid Corporation, having offices in Spartanburg, South Carolina was filled with purified water. The purified water was maintained at a temperature between 65 °F and 85 °F (between about 18.3 °C and 29.4 °C), which was within the range of normal ambient conditions (about 73 °F (about 23 °C) and about 50% relative humidity) at which this test was conducted. An 8 inch by 8 inch (about 20.3 cm by 20. 3 cm) square sample of the test material was placed such that the test head reservoir was

covered completely. The sample was subjected to a standardized water pressure, increased at a constant rate until leakage was observed on the outer surface of the sample material. Hydrostatic pressure resistance was measured at the first sign of leakage in three separate areas of the sample. This test was repeated for forty specimens of each sample material. The hydrostatic pressure resistance results for each specimen were averaged and recorded in millibars. Again, a higher value indicates greater resistance to water penetration and is desirable for barrier applications.

Alcohol: The alcohol repellency test is designed to measure the resistance of nonwoven fabrics to penetration by low surface tension liquids, such as alcohol/water solutions. Alcohol repellency was tested according to the test procedure described as follows. In this test, a fabric's resistance to penetration by low surface energy fluids is determined by placing 0.1 ml of a specified volume percentage of isopropyl alcohol (IPA) solution in several different locations on the surface of the fabric and leaving the specimen undisturbed for 5 minutes. In this test, 0.1 ml of serially diluted isopropyl alcohol and distilled water solutions, ranging from 60 volume percent to 100 volume percent in increments of 10 percent, are placed on a fabric sample arranged on a flat surface. After 5 minutes, the surface is visually inspected and the highest concentration retained by the fabric sample is noted. For example, if the minimum value is a 70 % IPA solution, i.e. a 70 % IPA solution is retained by the fabric but an 80 % solution penetrates through the fabric to the underlying surface. The grading scale ranges from 0 to 5, with 0 indicating the IPA solution wets the fabric and 5 indicating maximum repellency. Unless stated otherwise, the percent alcohol (IPA) repellency reported indicates the maximum volume percent of IPA that could be added to water while still retaining a 5 rating on the scale at all points of the fabric tested. This procedure is a modification of INDA Standard Test No. IST 80.9-74 (R-82).

Resistance to Blood Penetration (RBP): The blood strikethrough or resistance to blood penetration of a fabric is a measure of the amount of blood which penetrates the fabric at a particular pressure. The blood strikethrough is performed by weighing a blotter placed next to the fabric before and after the test which consists of applying 1 pound per square inch gauge (psig) pressure to the side of the fabric away from the blotter, which side has blood thereon. The pressure is ramped up over approximately 10 seconds and removed when it reaches 1 psig. The difference in the weight of the blotter before and after the test in grams represents the amount of blood which has penetrated the fabric.

Grab Tensile test: The grab tensile test is a measure of breaking strength and elongation or strain of a fabric when subjected to unidirectional stress. This test is known in the art and conforms to the specifications of Method 5100 of the Federal Test Methods Standard 191A. The results are expressed in pounds or grams to break and percent stretch before breakage. Higher numbers indicate a stronger, more stretchable fabric. The term "load" means the maximum load or force, expressed in units of weight, required to break or rupture the specimen in a tensile test. The term "total energy" means the total energy under a load versus elongation curve as expressed in weight-length units. The term "elongation" means the increase in length of a specimen during a tensile test. The grab tensile test uses two clamps, each having two jaws with each jaw having a facing in contact with the sample. The clamps hold the material in the same plane, usually vertically, separated by 3 inches (76 mm) and move apart at a specified rate of extension. Values for grab tensile strength and grab elongation are obtained using a sample size of 4 inches (102 mm) by 6 inches (152 mm), with a jaw facing size of 1 inch (25 mm) by 1 inch, and a constant rate of extension of 300 mm/min. The sample is wider than the clamp jaws to give results representative of effective strength of fibers in the clamped width combined with additional strength contributed by adjacent fibers in the fabric. The specimen is clamped in, for example, a Sintech 2 tester, available from the Sintech

Corporation, 1001 Sheldon Drive, Cary, North Carolina 27513, an Instron Model TM, available from the Instron Corporation, 2500 Washington Street, Canton, Massachusetts 02021, or a Thwing-Albert Model INTELLECT II available from the Thwing-Albert Instrument Co., 10960 Dutton Road, Philadelphia, Pennsylvania 19154. This closely simulates fabric stress conditions in actual use. Results are reported as an average of three specimens and may be performed with the specimen in the cross direction (CD) or the machine direction (MD).

Antistatic properties were measured according to INDA Standard Test 40.2-92.

Porosity results were obtained by Frazier Porosity tests, ASTM Standard D737 "Air Permeability of Textile Fabrics," also Method 5450 Federal Test Methods Standard No. 191A, except that the specimen size is 8 inches by 8 inches.

Definitions

As used herein and in the claims, the term "comprising" is inclusive or open-ended and does not exclude additional unrecited elements, compositional components, or method steps.

As used herein, the term "nonwoven fabric or web" means a web having a structure of individual fibers or threads which are interlaid, but not in an identifiable manner as in a knitted fabric. Nonwoven fabrics or webs have been formed from many processes such as for example, meltblowing processes, spunbonding processes, and bonded carded web processes. The basis weight of nonwoven fabrics is usually expressed in ounces of material per square yard (osy) or grams per square meter (gsm) and the fiber diameters useful are usually expressed in microns or an equivalent but more recognized term, micrometers. (Note that to convert from osy to gsm, multiply osy by 33.91). As used herein the term "spunbonded fibers" refers to small diameter fibers which are formed by extruding molten thermoplastic material as filaments from a plurality of fine, usually circular

capillaries of a spinneret with the diameter of the extruded filaments then being rapidly reduced as by, for example, in U.S. Patent no. 4,340,563 to Appel et al., U.S. Patent no. 3,692,618 to Dorschner et al., U.S. Patent no. 3,802,817 to Matsuki et al., U.S. Patent nos. 3,338,992 and 3,341,394 to Kinney, U.S. Patent no. 3,502,763 to Hartman, and U.S. Patent no. 3,542,615 to Dobo et al. Spunbond fibers are generally not tacky when they are deposited onto a collecting surface. Spunbond fibers are generally continuous and have average diameters (from a sample of at least 10) larger than 7 microns, more particularly, between about 10 and 20 microns. The fibers may also have shapes such as those described in U.S. Patent nos. 5,277,976 to Hogle et al., U.S. Patent no. 5,466,410 to Hills and 5,069,970 and 5,057,368 to Largman et al., which describe fibers with unconventional shapes.

As used herein, the term "meltblown fibers" means fibers formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or filaments into converging high velocity, usually hot, gas (e.g. air) streams which attenuate the filaments of molten thermoplastic material to reduce their diameter, which may be to microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly dispersed meltblown fibers. Such a process is disclosed, for example, in U.S. Patent no. 3,849,241 to Butin et al. Meltblown fibers are microfibers which may be continuous or discontinuous, are generally smaller than 10 microns in average diameter, and are generally tacky when deposited onto a collecting surface.

As used herein, the term "multilayer laminate" means a laminate wherein some of the layers, for example, are spunbond and some meltblown such as a spunbond/meltblown/spunbond (SMS) laminate and others as disclosed in U.S. Patent no. 4,041,203 to Brock et al., U.S. Patent no. 5,169,706 to Collier, et al, U.S. Patent no. 5,145,727 to Potts et al., U.S. Patent no. 5,178,931 to Perkins et al. and U.S. Patent no.

5,188,885 to Timmons et al. Such a laminate may be made by sequentially depositing onto a moving forming belt first a spunbond fabric layer, then a meltblown fabric layer and last another spunbond layer and then bonding the laminate in a manner described below. Alternatively, the fabric layers may be made individually, collected in rolls, and combined in a separate bonding step. Such fabrics usually have a basis weight of from about 0.1 to 12 osy (3 to 400 gsm), or more particularly from about 0.75 to about 3 osy. Multilayer laminates may also have various numbers of meltblown layers or multiple spunbond layers in many different configurations and may include other materials like films (F) or coform materials, e.g. SMMS, SM, SFS, etc.

As used herein, the term "polymer" generally includes but is not limited to, homopolymers, copolymers, such as for example, block, graft, random and alternating copolymers, terpolymers, etc. and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term "polymer" shall include all possible geometrical configurations of the molecule. These configurations include, but are not limited to isotactic, syndiotactic and random symmetries.

As used herein, the term "conjugate fibers" refers to fibers which have been formed from at least two polymers extruded from separate extruders but spun together to form one fiber. Conjugate fibers are also sometimes referred to as multicomponent or bicomponent fibers. The polymers are usually different from each other though conjugate fibers may be monocomponent fibers. The polymers are arranged in substantially constantly positioned distinct zones across the cross-section of the conjugate fibers and extend continuously along the length of the conjugate fibers. The configuration of such a conjugate fiber may be, for example, a sheath/core arrangement wherein one polymer is surrounded by another or may be a side by side arrangement, a pie arrangement or an "islands-in-the-sea" arrangement. Conjugate fibers are taught in U.S. Patent no. 5,108,820 to Kaneko et al., U.S. Patent no. 4,795,668 to Krueger et al., U.S. Patent no.

5,540,992 to Marcher et al. and U.S. Patent no. 5,336,552 to Strack et al. Conjugate fibers are also taught in U.S. Patent no. 5,382,400 to Pike et al. and may be used to produce crimp in the fibers by using the differential rates of expansion and contraction of the two (or more) polymers. Crimped fibers may also be produced by mechanical means and by the process of German Patent no. DT 25 13 251 A1. For two component fibers, the polymers may be present in ratios of 75/25, 50/50, 25/75 or any other desired ratios. The fibers may also have shapes such as those described in U.S. Patent nos. 5,277,976 to Hogle et al., U.S. Patent no. 5,466,410 to Hills and 5,069,970 and 5,057,368 to Largman et al., which describe fibers with unconventional shapes.

As used herein, "thermal point bonding" involves passing a fabric or web of fibers to be bonded between a heated calender roll and an anvil roll. The calender roll is usually, though not always, patterned in some way so that the entire fabric is not bonded across its entire surface, and the anvil roll is usually flat. As a result, various patterns for calender rolls have been developed for functional as well as aesthetic reasons. One example of a pattern has points and is the Hansen Pennings or "H&P" pattern with about a 30% bond area with about 200 bonds/square inch as taught in U.S. Patent no. 3,855,046 to Hansen and Pennings. The H&P pattern has square point or pin bonding areas wherein each pin has a side dimension of 0.038 inches (0.965 mm), a spacing of 0.070 inches (1.778 mm) between pins, and a depth of bonding of 0.023 inches (0.584 mm). The resulting pattern has a bonded area of about 29.5%. Another typical point bonding pattern is the expanded Hansen Pennings or "EHP" bond pattern which produces a 15% bond area with a square pin having a side dimension of 0.037 inches (0.94 mm), a pin spacing of 0.097 inches (2.464 mm) and a depth of 0.039 inches (0.991 mm). Another typical point bonding pattern designated "714" has square pin bonding areas wherein each pin has a side dimension of 0.023 inches, a spacing of 0.062 inches (1.575 mm) between pins, and a depth of bonding of 0.033 inches (0.838 mm). The resulting pattern has a bonded area of

about 15%. Yet another common pattern is the C-Star pattern which has a bond area of about 16.9%. The C-Star pattern has a cross-directional bar or "corduroy" design interrupted by shooting stars. Other common patterns include a diamond pattern with repeating and slightly offset diamonds with about a 16% bond area and a wire weave pattern looking as the name suggests, e.g. like a window screen, with about a 19% bond area. Typically, the percent bonding area varies from around 10% to around 30% of the area of the fabric laminate web. As is well known in the art, the spot bonding holds the laminate layers together as well as imparts integrity to each individual layer by bonding filaments and/or fibers within each layer.

As used herein, the term "infection control product" means medically oriented items such as surgical gowns and drapes, face masks, head coverings like bouffant caps, surgical caps and hoods, footwear like shoe coverings, boot covers and slippers, wound dressings, bandages, sterilization wraps, wipers, garments like lab coats, coveralls, aprons and jackets, patient bedding, stretcher and bassinet sheets, and the like.

As used herein the term "antistatic agent " refers to a reagent capable of preventing, reducing or dissipating static electrical charges that may be produced on textile materials such as nonwoven surgical gowns. Antistatic agents include ZELEC® organic phosphate esters available from Stepan Chemical and QUADRASTAT® mono- and di- substituted potassium isobutyl phosphate from Manufacturers Chemical of Cleveland, Tennessee.

Composition percent amounts herein are expressed by weight unless otherwise indicated.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to treatment of nonwoven substrates to impart desired properties, particularly alcohol repellency, to the nonwoven substrates. Suggested

nonwoven substrates include, but are not limited to, nonwoven fabrics including laminates that include at least one meltblown (M) layer and/or at least one spunbond layer (S), spunbond/meltblown (SM) laminates, spunbond/meltblown/spunbond (SMS) laminates, spunbond/film/spunbond (SFS) laminates, spunbond/film/spunbond/meltblown/spunbond (SFSMS) laminates and spunbond/film/film/spunbond (SFFS) laminate and laminates and combinations thereof. The invention also relates to resulting nonwoven fabrics having, for example, one surface that is alcohol repellent and the other that has antistatic properties suitable for use in the manufacture of infection control medical products including surgical gowns and sterilization wrap. Such nonwoven fabrics also have excellent barrier properties as measured by hydrostatic head and are useful as surgical fabrics and as components in surgical gowns, drapes, surgical packs and so forth. Advantageously, fabrics and fabric laminates of the present invention can be made at lower basis weights while maintaining acceptable barrier properties.

The present invention is described by reference to the test methods and definitions described above and to specific embodiments of the invention, one or more examples of which are set forth below. Each example is provided by way of explanation of the invention, not as a limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in this invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention cover such modifications and variations as come within the scope of the appended claims and their equivalents. Other objects, features and aspects of the present invention are disclosed in or are obvious from the following detailed description. It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary

embodiments only, and is not intended as limiting the broader aspects of the present invention, which broader aspects are embodied in the exemplary constructions.

The present invention provides an improved method of topically treating nonwoven fabrics with a fluoropolymer chemistry that improves the alcohol repellency of the fabric while minimizing any negative effect on the water barrier of the fabric. In one exemplary embodiment, the method of treating nonwoven fabrics includes treating a nonwoven fabric with a solution or a suspension that includes a non-ionic fluoropolymer, no antistatic agent or essentially no antistatic agent. It is believed that inclusion of antistatic agents negatively effect the water repellency of the fabric. Desirably, the amount of antistatic agent in the treatment solution is less than 0.05 weight percent, even more desirably, less than 0.005 weight percent. Antistatic agents have been observed to destabilize ionic fluoropolymer suspensions of charged fluoropolymers in the treatment bath solution or suspension. Destabilization of the treatment bath is undesirable and causes coagulation and filter plugging during the treatment process. In one desirable embodiment, the present invention provides a method of topically treating surgical fabric that includes treating the fabric with a solution or suspension that includes a non-ionic fluoropolymer. Non-ionic fluoropolymers include, but are not limited to, non-ionic fluoroalkyl acrylate homopolymers and copolymers, such as fluorinated siloxanes, fluorinated silicones, fluorinated urethanes and so forth. A non-ionic fluoropolymer was obtained from Daikin America, Inc. of Orangeberg, New York an affiliate of Daikin Industries, Ltd of Japan. under the trade designations UNIDYNE® S-1072 and UNIDYNE® TG-KC02. UNIDYNE® TG KC-O2 is a non-ionic fluoroalkyl acrylate copolymer emulsion that consists essentially of about 30 to 31 weight percent of a non-ionic fluoroalkyl acrylate copolymer, about 60 to 62 weight percent of water and about 8 weight percent of tripropylene glycol. Another non-ionic fluoropolymer that is commercially available from Mitsubishi International Corporation of New York is

REPEARL F-7105. REPEARL F-7105 is an emulsion of about 30 weight percent of a non-ionic fluoroacrylate copolymer, about 60 weight percent of water and about 10 weight percent of dipropylene glycol. It is suggested that the treatment solution or suspension that includes the non-ionic fluoropolymer include no or essentially no anionic antistatic agent. An antistatic agent, anionic or otherwise, can be applied to the treated fabric after the water repellency treatment and on only one side so as to minimize negative effects on water repellency. It is believed that using a non-ionic fluoropolymer treatment rather than an ionic fluoropolymer treatment reduces electrostatic interactions in the treatment solution or suspension and improves bath stability. It is also believed that electrostatic interactions hinder adsorption of the treatment solution onto the fabric.

Antistatic agents are reagents that prevent or greatly reduce electrical charges that may be produced on textile materials and are also referred to as antistats. Antistatic agents include organic phosphate esters such as ZELEC KC, an alkyl phosphate ester from Stepan Chemical that may include mono- and disubstituted potassium n-butyl phosphate and QUADRASTAT PIBK, mono- and di- substituted potassium isobutyl phosphate from Manufacturers Chemical of Cleveland, Tennessee.

Turning to the drawings, Figure 1 shows a web **10**, for example a nonwoven fabric web, traveling from right to left. At saturation spray device **12**, a fluorocarbon spray is applied to both sides. Squeeze nip rolls **14** remove excess fluorocarbon and vacuum extractor **16** removes additional treatment composition as web **10** travels over guide rolls **18**. At treatment station **20** an antistat is applied to one side only of web **10** by spray device **22** and at a point preferably prior to full curing of the fluorocarbon. Web **10** is then dried by contact with steam cans **24**. It is suggested that only one side, the body side, of a nonwoven fabric that is to be used as a surgical gown or other barrier is treated with an antistat so that the antistat does not interfere with the water repellency of the exterior side of the fabric.

Figure 2 shows a process using a foam applicator to apply the fluorochemical instead of an antistatic spray device **22** as in Figure 1. For Figure 2, the system may be the same as Figure 1 prior to the antistat spray **20** (Figure 1) and is not shown. In Figure 2, foam applicator **32** applies fluorocarbon composition as a foam. Excess is removed in the nip **34** between squeeze rolls **36**, and web **10** is directed over steam cans **24** for drying as in Figure 1.

Figure 3 shows schematically an exemplary second inline treatment step applied to web **40** having been previously treated as, for example, using the saturation spray device **12** of Figure 1. In this embodiment, web **40** is unwound from roll **42** and directed around guide roll **44** through printing station **46** including ink jet printhead **48** and web support platen/exhaust hood **50**. The web has applied to the surface facing the printhead a light application of the antistat. The web may then be directed by one or more drive rolls **52** and rewound into treated roll **54** or, optionally, otherwise processed.

Figure 4 shows a third embodiment where the foam applicator **32** is used to apply fluorocarbon to one side of web **10** and spray **22** to apply antistat to the opposite side at steam can **24**. Otherwise the process is like the process schematically illustrated in Figure 2.

Examples

The present invention is further described by the examples which follow. Such examples, however, are not to be construed as limiting in any way either the spirit or the scope of the present invention.

For those examples using SMS fabric, the general process for forming the fabric and treating it was as follows:

A spunbond/meltblown/spunbond (SMS) laminate consisting of about 35 weight percent of a first spunbond layer, about 30 weight percent of meltblown layer and about 35 weight percent of a second spunbond layer was formed as described in U.S. Patent

no. 4,041,203 to Brock et al. After forming, the SMS laminate was thermally bonded with a bonding roll resulting in about 15 percent bond area in a wire weave pattern. The fabrics produced for the examples had a basis weight of about 1.5 oz/yd^2 (51 gsm) or a basis weight of about 1 oz/yd^2 (about 41 gsm) as specified. After bonding, the SMS laminate was treated off line. Samples of the SMS laminate were treated by immersing a sample of the SMS laminate in a treatment solution as specified below. However, the SMS laminate can be treated in line, for example by passing the SMS laminate through a saturator containing a treatment bath as generally illustrated in Figure 1. The amount of non-ionic fluoropolymer emulsion needed in the treatment composition is dependent upon the level of alcohol repellency desired and generally believed to be dependent of the specific non-ionic fluoropolymer chosen and the exposure time of the substrate to the treatment composition. In general, the less time that a laminate is exposed to a treatment composition, the greater the amount of non-ionic fluoropolymer emulsion is suggested in the bath to obtain the level of fluorine on the substrate to achieve a targeted level of repellency. Each of the examples was prepared in the same manner. Samples of dried, treated material of each example were tested for alcohol repellency, water barrier as measured by hydrostatic head and fluorine add-on level to determine the add-on efficiency of the method.

The treatment compositions varied as specified in the each of the following Examples. A fluorine containing compound, for example a non-ionic fluoropolymer, was added to increase the isopropanol repellency of the finished, dried laminate. An alcohol, for example octanol, was added to aid in wetting out the laminate completely. As the water is dried off the laminate in a later step, the alcohol is volatilized. The amount of octanol used was typically 0.25 percent by weight in the aqueous treatment bath. For example in a commercial inline process, after saturation, which results in about 300 percent wet pickup based on fabric weight, the fabric can be run through a squeeze nip,

resulting in a reduction in the wet pickup to about 100 percent and then over a dewatering vacuum apparatus, further reducing the wet pickup to about 40 percent. After drying using steam cans, the treated fabric ca be wound on cardboard cores.

No antistatic agent was applied to the Examples. However, an antistatic agent could be included in the treatment bath or added at as a later treatment step. For example, an organic phosphate ester antistatic agent could be applied to one or both surfaces of the fabric via an atomized spray apparatus. The amount of fluoropolymer emulsion included in the treatment composition can vary and is dependent on several factors including, but not limited to, the level of alcohol repellency desired and the time the substrate is exposed to the treatment solution. In general, the less time that the laminate is exposed to the fluoropolymer containing treatment the more fluoropolymer is needed to reach a targeted level of repellency. For the Daikin UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension and the process conditions chosen in the Examples below, treatment compositions containing from about 0.1 to about 1 weight percent of the non-ionic fluoropolymer suspension were used. The amount of fluoropolymer is also believed to be dependent on the particular fluoropolymer that is selected.

The treatment solutions for each example were prepared as follows. The specified weight of fluoropolymer emulsion was added to water in a 1000 ml beaker. The non-ionic fluoropolymer emulsion was initially mixed into the water using a spatula and then placed under a Ross high shear mixer. Under vigorous mixing, the specified amount of other ingredients, if any, and the specified amount of octanol was added to the mixture and further mixed a high speed for an additional 2 minutes. The emulsion was then transferred to a pan large enough to accommodate an 8-inch by 10-inch sample of the SMS fabric. An 8-inch by 10-inch sample of the SMS fabric was then completely submerged in the emulsion and flipped over and submerged in the emulsion again to ensure complete wet out. The saturated SMS fabric was then run through an

Atlas laboratory ringer equipped with 100 lbs equivalent weights to reduce the wet pick up (WPU). The resulting emulsion was then fed into a saturation pan and continuously added to maintain the required amount of fluid necessary to saturate the SMS web passing through the equipment. The resulting wet pick up (WPU) of the formulation on the SMS was 300 percent by weight of the SMS. The WPU can be calculated as WPU = 100 % x (wet weight – dry weight)/dry weight. The SMS web then passed through a wringer capable of reducing the wet pick up from 300 percent down to 100 percent. The liquid that was removed from the sheet was allowed to recirculate back into the saturation pan. Finally, the treated SMS web passed through a large forced hot air drying unit capable of reducing the WPU from 100 percent to bone dry (0 percent WPU).

The percent fluorine add-on level on the samples was determined by an independent laboratory (Galbraith Laboratories of Knoxville, Tennessee) using an elemental analysis technique. The hydrostatic head of the samples was measured according to Federal Test Standard 191A, Method 5514. The alcohol repellency of the samples was measured by placing 0.1ml of a specified percentage of isopropyl alcohol aqueous solution in several different locations on the surface of the fabric and leaving the specimen undisturbed for 5 minutes. The grading scale ranges from 0 to 5, with 0 indicating the IPA solution wets the fabric and 5 indicating maximum repellency. Unless stated otherwise, the percent alcohol (IPA) repellency reported indicates the maximum volume percent of IPA that could be added to water while still retaining a 5 rating on the scale at all points of the fabric tested. This procedure is a modification of INDA Standard Test No. IST 80.9-74 (R-82).

Comparative Example A

Comparative Example A consisted of untreated 1.5 osy SMS laminate fabric. The alcohol repellency of Comparative Example A was measured at 20 percent IPA. The water barrier property of Comparative Example A was measured at a hydrostatic head of

84.9 ± 6.2 mBar. The untreated 1.5 osy SMS fabric provides desirable water barrier but does not provide acceptable alcohol repellency.

Comparative Example B

Comparative Example B consisted of untreated 1.5 osy SMS laminate fabric that was treated in a bath that included an ionic fluoropolymer and an anionic antistatic agent. The aqueous treatment bath for Comparative Example B consisted of water in which was dissolved, or at least suspended, 0.69 weight percent of a cationic fluoropolymer suspension from Daikin America, Inc. identified as UNIDYNE® TG-KC01 and 0.30 weight percent of QUADRASTAT PIBK anionic antistatic agent obtained from Manufacturers Chemical of Cleveland, Tennessee. The alcohol repellency of Comparative Example B was measured at 90 percent IPA. The water barrier property of Comparative Example B was measured at a hydrostatic head of 46.3 ± 3.1 mBar. And, the fluorine add-on level of Comparative Example B was measured at 0.36 weight percent.

Example 1

Example 1 is an example of a dip saturation treatment method of treating a 1.5 osy SMS nonwoven surgical fabric with an aqueous treatment solution that includes a nonionic fluoropolymer and no antistatic agent. The treatment bath suspension of Example 1 consisted of a water bath in which was dissolved, or at least suspended, 0.85 weight percent of a non-ionic fluoropolymer suspension UNIDYNE® TG-KC02 obtained from Daikin America, Inc. of Orangeberg, New York and 0.25 weight percent of octanol (a short chain alcohol that was used as a wetting agent).

The UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension obtained from Daikin contained about 30 weight percent of non-ionic fluoropolymer solids and the wet pick-up rate of the treatment solution on the SMS fabric for Example 1 was about 116 weight percent. The non-ionic fluoropolymer treated SMS surgical fabric was dried for 2 minutes at about 105 °C. The alcohol repellency of the dried, non-ionic fluoropolymer

treated Example 1 was measured at 60 percent IPA.

Example 2

The treatment bath suspension of Example 2 consisted of a water bath in which was dissolved, or at least suspended, 1.00 weight percent of UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension obtained from Daikin and 0.25 weight percent of octanol. The wet pick-up rate of the treatment solution on the 1.5 osy SMS fabric for Example 2 was about 116 weight percent. The non-ionic fluoropolymer treated SMS fabric was dried for 2 minutes at about 105 °C. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 2 was measured at 80 percent IPA.

Comparative Example C

Comparative Example C consisted of untreated 1 osy SMS laminate fabric. The alcohol repellency of Comparative Example A was measured at 20 percent IPA. The water barrier property of Comparative Example A was measured at a hydrostatic head of 47.3 ± 5.3 mBar. The untreated 1 osy SMS fabric provides desirable water barrier but does not provide acceptable alcohol repellency.

Example 3

The treatment bath suspension of Example 3 consisted of a water bath in which was dissolved, or at least suspended, 0.80 weight percent of UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension obtained from Daikin and 0.25 weight percent of octanol. 1 osy SMS fabric was treated offline after the SMS fabric was produce by running the SMS through the treatment solution at a rate of about 50 feet per minute resulting in a wet pick-up rate of about 99 weight percent. The wet SMS fabric was then passed through a nip at a pressure of about 50 psi and dried over a drying can at about 245 °F. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 3 was measured at 100 percent IPA. The water barrier property of Example 3 was measured at a hydrostatic head of 47.2 ± 1.5 mBar.

Example 4

The treatment bath suspension of Example 4 consisted of a water bath in which was dissolved, or at least suspended, 0.60 weight percent of UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension obtained from Daikin and 0.25 weight percent of octanol. 1 osy SMS fabric was treated offline by running the SMS through the treatment solution at a rate of about 50 feet per minute resulting in a wet pick-up rate of about 99 weight percent. The wet SMS fabric was then passed through a nip at a pressure of about 50 psi and dried over a drying can at about 245 °F. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 4 was measured at 100 percent IPA. The water barrier property of Example 4 was measured at a hydrostatic head of 48.1 ± 3.3 mBar.

Example 5

The treatment bath suspension of Example 5 consisted of a water bath in which was dissolved, or at least suspended, 0.40 weight percent of UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension obtained from Daikin and 0.25 weight percent of octanol. 1 osy SMS fabric was treated offline by running the SMS through the treatment solution at a rate of about 50 feet per minute resulting in a wet pick-up rate of about 99 weight percent. The wet SMS fabric was then passed through a nip at a pressure of about 50 psi and dried over a drying can at about 245 °F. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 5 was measured at 95 percent IPA. The water barrier property of Example 5 was measured at a hydrostatic head of 52.4 ± 2.8 mBar.

Example 6

The treatment bath suspension of Example 6 consisted of a water bath in which was dissolved, or at least suspended, 0.20 weight percent of UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension obtained from Daikin and 0.25 weight percent of octanol. 1 osy SMS fabric was treated offline by running the SMS through the treatment solution

at a rate of about 50 feet per minute resulting in a wet pick-up rate of about 99 weight percent. The wet SMS fabric was then passed through a nip at a pressure of about 50 psi and dried over a drying can at about 245 °F. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 6 was measured at about 80 percent IPA. The water barrier property of Example 6 was measured at a hydrostatic head of 49.3 ± 2.3 mBar.

Example 7

The treatment bath suspension of Example 7 consisted of a water bath in which was dissolved, or at least suspended, 0.10 weight percent of UNIDYNE® TG-KC02 non-ionic fluoropolymer suspension obtained from Daikin and 0.25 weight percent of octanol. 1 osy SMS fabric was treated offline by running the SMS through the treatment solution at a rate of about 50 feet per minute resulting in a wet pick-up rate of about 99 weight percent. The wet SMS fabric was then passed through a nip at a pressure of about 50 psi and dried over a drying can at about 245 °F. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 7 was measured at about 40 percent IPA. The water barrier property of Example 7 was measured at a hydrostatic head of 48.3 ± 2.8 mBar.

Example 8

The treatment bath suspension of Example 8 consisted of a water bath in which was dissolved, or at least suspended, 1.50 weight percent of a non-ionic fluoropolymer suspension REPEARL F-7105 obtained from Mitsubishi International Corporation of New York and 0.25 weight percent of octanol (a short chain alcohol that was used as a suspending agent) obtained from Aldrich Chemical. The REPEARL F-7105 non-ionic fluoropolymer suspension obtained from Mitsubishi contained about 30 weight percent of non-ionic fluoropolymer solids and the wet pick-up rate of the treatment solution on the 1 osy SMS fabric was about 120 weight percent. The non-ionic fluoropolymer treated 1

osy SMS fabric was dried for 2 minutes at about 105 °C. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 8 was measured at 40 percent IPA.

Example 9

The treatment bath suspension of Example 9 consisted of a water bath in which was dissolved, or at least suspended, 2.25 weight percent of REPEARL F-7105 non-ionic fluoropolymer suspension and 0.25 weight percent of octanol. The wet pick-up rate of the treatment solution on the 1 osy SMS fabric for Example 9 was about 90 weight percent. The non-ionic fluoropolymer treated 1 osy SMS fabric was dried for 2 minutes at about 105 °C. The alcohol repellency of the dried, non-ionic fluoropolymer treated Example 9 was measured at 50 percent IPA.

A summary of the experimental data is present in Table 1 below.

Table 1.

Example Number	Treatment Solution Composition	Isopropyl Alcohol Repellency	Hydrostatic Head (mBar)
Control A	untreated 1.5 osy SMS	20	84.9 ± 6.2
Control B	1.5 osy SMS treated w/ 0.69 w/o TG-KC01 and 0.30 w/o QUADRASTAT PIBK	90	46.3 ± 3.1
1	1.5 osy SMS treated w/ 0.85 w/o TG-KC02	60	-
2	1.5 osy SMS treated w/ 1.00 w/o TG-KC02	80	-
Control C	untreated 1 osy SMS	20	47.3 ± 5.3
3	1 osy SMS treated w/ 0.80 w/o TG-KC02	100	47.2 ± 1.5
4	1 osy SMS treated w/ 0.60 w/o TG-KC02	100	48.1 ± 3.3
5	1 osy SMS treated w/ 0.40 w/o TG-KC02	95	52.4 ± 2.8
6	1 osy SMS treated w/ 0.20 w/o TG-KC02	80	49.3 ± 2.3
7	1 osy SMS treated w/ 0.10 w/o TG-KC02	40	48.3 ± 2.8
8	1 osy SMS treated w/ 1.50 w/o REPEARL F-7105	40	-
9	1 osy SMS treated w/ 2.25 w/o REPEARL F-7105	50	-

Although various embodiments of the invention have been described above using specific terms, devices, and methods, such description is for illustrative purposes only. The words used are words of description rather than of limitation. It is to be understood that changes and variations may be made by those of ordinary skill in the art

without departing from the spirit or scope of the present invention, which is set forth in the following claims. In addition, it should be understood that aspects of the various embodiments may be interchanged both in whole or in part. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained therein.